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ABSTRACT

A study examined whether informed training and computer mediated text improved reading comprehension levels, whether computer mediated text is effective when it is preceded by informed strategy training, and whether informed strategy training leads to higher levels of metacognitive awareness and more frequent use of computer assistance options. Subjects were 90 fifth through seventh graders in an upper midwestern school. After the experimental group received informed strategy training via computer assisted instruction, experimentals and controls read computer mediated texts with or without computer assistance options. Results indicated that subjects who received informed strategy training had significantly higher levels of metacognitive awareness and significantly higher levels of computer option use. However, neither informed strategy training nor computer mediated text led to higher on-line or post-intervention reading comprehension levels. (Contains 88 references and 4 tables of data.) (Author/RS)

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The Effects of Informed Strategy Training and Computer Mediated Text on Comprehension Monitoring and Reading Comprehension

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Successful reading comprehension is thought to be related to the application of metacognitive strategies while reading. Poor comprehenders tend not to use metacognitive skills to monitor their reading comprehension even though they seem to possess the skills. Reading research has found that informed training in comprehension monitoring and repair strategies can lead to improved monitoring and comprehension. Informed training emphasizes teaching students when, how, and why reading comprehension strategies should be used. Mixed results have been obtained when computer mediated text is used as a method of increasing monitoring and comprehension. The current investigation hypothesized that both informed training and computer mediated text would improve reading comprehension levels, and that computer mediated text would be most effective when it was preceded by informed strategy training. It was also hypothesized that informed strategy training would lead to higher levels of metacognitive awareness and more frequent use of computer assistance options. The subjects were 90 fifth through seventh graders in an upper midwestern school. After the experimental group received informed strategy training via computer assisted instruction, experimentals and controls read computer mediated text with or without computer assistance options. The study found that subjects who received informed strategy training had significantly higher levels of metacognitive awareness and significantly higher levels of computer option use. However, neither informed strategy training nor computer mediated text led to higher on-line or post-intervention reading comprehension levels.

Introduction

Many children do not develop into thoughtful and independent readers who are able to efficiently learn from text. While their decoding skills may be adequate they often fail to develop and implement cognitive and metacognitive strategies which are thought to increase comprehension. Development of a cognitive model of learning has led to increased interest in the relationship between the concept of metacognition and reading comprehension (Billingsley & Wildman, 1990). Research on metacognition, the knowledge about and regulation of one's own learning, has found support for applications which attempt to increase a reader's metacognitive activity as means of improving reading comprehension (Paris, Wasik, & Van der Westhuizen, 1988).

Research on reading has consistently found that poor readers are not likely to spontaneously use metacognitive skills to aid their reading comprehension (Chan, Cole, & Barfett, 1987; Short & Ryan, 1984). Poor comprehenders can be

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distinguished from good comprehenders by their deficient knowledge and use of metacognitive reading activities (Haynes, Kapinus, Malouf, & MacArthur, 1985; Knight, 1989). In some studies, the direct instruction of metacognitive skills seems to have a substantial effect on reading comprehension (Haller, Child, & Walberg, 1988; Wong, 1987). However, explicit instruction in cognitive and metacognitive strategies designed to facilitate comprehension is seldom provided by classroom teachers (Brown, Palincsar, & Armbruster, 1984; Paris, Cross, & Lipson, 1984).

Even when specific strategy instruction is provided, many students fail to transfer and maintain the skills (Paris & Oka, 1989). Without the motivation and/or continued assistance and encouragement to utilize effective reading comprehension strategies, many readers fail to maintain significant improvements in comprehension (Paris & Oka). Computer-assisted instruction, which has been shown to effectively reinforce classroom instruction (Kulik, Banger, & Williams, 1983), has seldom been employed in the training and maintenance of cognitive and metacognitive reading strategies. More research is needed on the effects that specially designed computer-assisted reading programs may have on the utilization of cognitive and metacognitive reading processes, and ultimately, on reading comprehension itself (Haynes, Kapinus, Malouf, & MacArthur, 1985).

There has been extensive investigation of individual differences in the development of reading skills among young readers. Much of the research has focused on readers who have difficulties learning how to proficiently extract meaning from text. One model of reading which has been proposed is the interactive model (Weisberg, 1988). The interactive model theorizes that comprehension is best accomplished when the reader actively engages the text in an attempt to construct meaning. The interactive reader uses metacognitive processes while reading (Crismore & Wang, 1985; Langer, 1986). Passive, noninteractive reading is thought to limit understanding of text (Scardamalia & Bereiter, 1984). Evidence indicates that most passive readers possess the abilities to read interactively but simply do not implement the metacognitive and cognitive processes involved (Baker, 1982; Bos & Filip, 1984; Short & Ryan, 1984; Wong, 1980, 1987).

Metacognition

The term "metacognition" was coined by Flavell (1979) but it was primarily Baker and Brown (1984a; 1984b) who developed the construct of metacognition as

it relates to reading. Metacognition consists of two distinct components --- awareness and regulation of one's own cognitive processes (Flavell, 1979). Metacognitive awareness or knowledge refers to an individual's knowledge of his or her cognitive resources in relation to the task (Schmitt & Newby, 1986). For example, the child is aware that he or she lacks relevant background knowledge or that different purposes of reading demand different reading strategies (Brown, Palincsar, & Armbruster, 1984). From an information processing perspective, metacognitive knowledge is viewed as a form of declarative knowledge (Paris & Jacobs, 1984). It is generally assumed (Schmitt & Newby, 1986) that knowledge of relevant cognitive processes and strategies precedes the strategic self-control of behavior.

As individuals become aware of their cognitive processes, they are able to exercise control over them (Gordon, 1990). The control or regulatory function of metacognition encompasses procedural knowledge (Paris & Jacobs, 1984). While reading for comprehension, metacognitive regulation would involve monitoring, checking, and evaluating whether comprehension is proceding adequately, and the consequent implementation of fix-up or debugging strategies when comprehension failures occur (Armbruster, 1983).

Conditional knowledge

Many studies have found evidence that even when poor comprehenders possess the requisite declarative and procedural knowledge they fail to implement appropriate metacognitive strategies when the task and difficulties encountered warrant doing so (Bos & Filip, 1984; Short & Ryan, 1984; Wong, 1980). This finding led Paris, Cross, and Lipson (1984) to argue for the inclusion of a third information processing construct which they termed "conditional knowledge." Conditional knowledge is "knowing when and why" the utilization of a cognitive or metacognitive strategy might benefit the reader (Pressley, 1990). Strategy value information presented to a reader is geared towards demonstrating the self-efficacy that results from becoming an interactive reader (Schunk & Rice, 1987).

Conditional knowledge is viewed as essential to the enactment, transfer, and maintenance of metacognitive strategies (Brown, Campione, & Day, 1981; Paris, Lipson, & Wixson, 1983). Appropriately, many metacognitive strategy training programs, frequently referred to as "informed" training have included instruction and feedback to insure that the subjects understand the relevance, utility, and

benefits of using metacognitive reading skills (Paris & Oka, 1983).

Relationship between cognition and metacognition

While cognitive and metacognitive processes frequently interact, the construct of metacognition, by definition, is distinct from cognition (Lawson, 1984). Metacognition oversees cognition and strategic behavior but cognition can proceed smoothly in the absence of metacognition (Armbruster, 1983). Cognition usually operates below the level of consciousness until the automated flow of processing is interrupted by a task too difficult for the usual skills to handle (Paris, Lipson, & Wixson, 1983). Awareness of the interruption is a metacognitive function. In order to deal with the obstacle, metacognition evaluates the situation and decides on a course of action such as the invoking of cognitive strategies (Loper, 1982; Weisberg, 1988).

Cognitive strategies are intentional and purposeful behavior which rely on declarative and procedural knowledge. Metacognition is usually conscious behavior which relies on conditional knowledge as well as declarative and procedural. Evidence for the construct validity of metacognition was found by Slife, Weiss, and Bell (1985). With a sample of learning disabled students, they were able to empirically demonstrate that metacognitive skills were independent of cognitive skills.

Metacognition, cognitive monitoring, and comprehension monitoring are hierarchically related concepts (Baker & Brown, 1984a; Wagoner, 1983). Comprehension monitoring, also referred to as metacomprehension, is one type of cognitive monitoring, and cognitive monitoring is one component of metacognition. A large portion of cognitive monitoring while reading is actually comprehension monitoring.

Development of reading awareness

Although it is believed that metacognitive status varies with age (Cross & Paris, 1988), there are no known longitudinal or time-series studies to document its development. Investigators have found no clear developmental differences that apply to all individuals (Markman & Gorin, 1981). Even some college students and adults fail to display metacognitive awareness and strategies while reading (Crismore & Wang, 1985; Pressley, Ghatala, Pirie, & Woloshyn, 1990).

It is generally accepted that children under the age of eight have very little metacognitive awareness, and that children under the age of ten do not routinely

monitor their reading comprehension (Brown, 1980). Lack of awareness is indicated by such behaviors as being unable to accurately assess one's level of understanding, and being unaware of possible remediation strategies (Spires, 1990). Lack of comprehension monitoring is demonstrated by being unable to extract the main idea of a passage or by failure to detect textual inconsistencies such as contradictory statements within a paragraph (Brown).

In reading, metacognition involves the ongoing monitoring and evaluation of one's comprehension so that the goals and purposes of reading are achieved (Cross & Paris, 1988). A prerequisite to comprehension monitoring is an awareness that one of the primary purposes of reading is to extract meaning from text. Young readers (those in first and second grade) and readers who have comprehension deficiencies usually have limited awareness of the goals of reading, and limited awareness of what strategies they might employ when reading for understanding (Cross & Paris). For example, young and poor readers usually believe that decoding is the primary purpose of reading (Brown, Armbruster, & Baker, 1986; Davey, 1983; Garner, 1981). Young readers are also unaware that they must expend additional cognitive effort to make sense of the words they have decoded (Baker & Brown, 1984b).

Metacognitive awareness seems to develop rapidly between third and fifth grade along with a concomitant increase in the correlation between reading awareness and reading comprehension. Cross and Paris (1988) found correlations of .28 ($p < .01$) at third grade and .40 ($p < .001$) in fifth grade. Prior to third grade, the relationship between reading awareness and reading performance was inconsistent. Brown (1980), in her review of the literature, discovered that most studies indicated third grade as the level at which awareness is attained by the majority of children.

Development of comprehension monitoring

Once proper reading awareness has been acquired, the regulation of reading does not necessarily occur. Comprehension monitoring does not seem to be consistently utilized by the average reader until about sixth grade (Brown, 1980). Apparently, development of the ability to monitor one's comprehension precedes consistent monitoring. For example, a group of 11 year olds were observed to consistently miss explicitly contradictory material in passages. But when directed to expect and identify textual inconsistencies, they found significantly more

inconsistencies (Markman & Gorin, 1981). The finding that error detection, one way of operationalizing comprehension monitoring (Zabrucky & Ratner, 1990), improves when subjects are instructed to find problems with the text, has been replicated (Wagoner, 1983).

Without being directed to do so, poor readers seldom correct impediments to comprehension. Myers and Paris (1978) found that the top 50 percent of young readers spontaneously corrected one in three errors while poor readers corrected only one in twenty. One explanation for the failure of less successful readers to detect textual inconsistencies is that they only evaluate propositions on an individual basis instead of relating passage propositions to each other to check for consistency (Garner, 1981; Markman & Gorin, 1981; Scardamalia & Bereiter, 1984).

If the goal of comprehension monitoring is to ensure that the reader understands the text, then the process involves more than the awareness that the text is not being assimilated (Singer & Donlan, 1982). The reader must also take action to rectify the comprehension inadequacy (Goetz, Palmer, & Haensly, 1983). Examples of some fix-up strategies include storing the inconsistency in long-term memory, re-reading the confusing passage (known as a lookback), looking ahead for more information, and consulting another source (Armbruster, 1983). In the current study, the term "comprehension monitoring" includes the application of fix-up and remediation strategies.

In Baker and Brown's (1984a) review of the literature, they found that a majority of studies had shown that ineffective comprehension monitoring is associated with poor comprehension. Some studies, such as Chan, Cole, and Barfett (1987), have found correlations between measures of comprehension monitoring and comprehension competence to range as high as .65 to .74. Other studies have failed to find significant positive correlations. For example, Bereiter and Bird (1985) found only a .26 (non-significant) correlation between comprehension monitoring and comprehension.

Computer mediated text

Recently, enhancement and utilization of metacognitive skills has been attempted via computer-mediated text (Balajthy, 1990; Carrasquillo & Nunez, 1988; Salomon, Globerson, & Guterman, 1989; Reinking, 1988; Reinking & Schreiner, 1985; Stevens, 1986). Computer mediated text is defined as the display of connected, written text under the control of a computer program (Reinking, 1987a).

The case has been made that computers can present more opportunities for readers to become actively involved with text than traditionally printed books can (Mandinach, 1987). Computers can actually interact with the reader, thereby enhancing the reader's interaction with the text (Balajthy, 1990; Reinking, 1986). Computer programs can be written which manipulate the content and structure of the text (Gerrell, 1983) and provide individualized adjunct aids. Computer mediated text can also monitor the reader's comprehension and encourage readers to examine impediments to comprehension (Reinking, 1987a). When a reader decides to make use of computer assistance, he or she is making a metacognitive decision (Kamil, 1987). Because a computer program can tabulate the strategies, such as lookbacks, that students are utilizing, teachers can then discuss with students the efficacy of their comprehension strategies (Balajthy & Reinking, 1985).

Computer mediated text can be programmed to encourage the application of active comprehension monitoring with the hope that readers will more actively monitor their comprehension in the future as a result of their exposure to interactive text (Reinking, 1987a). Computer manipulations that encourage more interactive processing and understanding include: requiring students to make a prediction before they are allowed to see the next page, highlighting the main idea, requiring criterion levels of passage comprehension before presenting more text, making lookbacks and lookaheads easy and convenient, providing an on-line dictionary and background information, offering a simpler version of the text, and graphic aids to convey meaning. It seems that individualized prompts and assistance can be more efficiently provided through computer mediated text than traditionally printed text. Allowing computers to provide poor readers with intermittent metacognitive prompts and easily accessible fix-up activities may be an effective way of encouraging and eliciting active and persistent comprehension monitoring (Blohm, 1987).

A general hypothesis consistent with metacognitive theory would be that readers whose comprehension difficulties can be resolved through computer manipulations and program options will outperform readers who do not have any computer options or assistance (Balajthy & Reinking, 1985). The current study will investigate the effects of the independent variables of informed training and computer mediated text on the dependent variables of comprehension monitoring and comprehension competence.

Hypotheses

The research hypotheses of the current study are:

1. Students who receive informed strategy training will attain a higher level of reading awareness and strategy knowledge than those who do not recieve informed strategy training.
2. Students who receive informed strategy training will select computer mediated text assistance options more frequently than those who do not receive informed training.
3. Students who read computer mediated text with options for assistance will demonstrate higher levels of reading comprehension than students who read computer mediated text without options for assistance.
4. Students who are provided with informed strategy training via computer assisted instruction prior to reading computer mediated text will demonstrate higher levels of reading comprehension than students not given informed instruction.
5. Students who receive informed strategy training via computer assisted instruction and then read computer mediated text with options for assistance will demonstrate the most improvement in reading comprehension levels.

Review of the Literature

Many reading comprehension studies since 1975 have attempted to elevate comprehension levels through training in metacognitive techniques (Brown, Palinscar, & Armbruster, 1984; Haller, Child, & Walber, 1988; Miller, 1985, 1987; Paris & Jacobs, 1984; Wong & Jones, 1982). Metacognitive treatments have included training in the following strategies: thinking aloud (Bereiter & Bird), finding the main idea (Graves, 1986), self-questioning (Wong, 1985), finding textual inconsistencies (Bos & Filip, 1984), assessing the correctness of one's responses (Davey, 1987), fitting the text to story schemata (Singer & Donlan, 1982), informing students of the value of comprehension monitoring (Paris & Jacobs, 1984), and teaching how to paraphrase, summarize, and predict (Brown & Palinscar, 1982). Typically, comprehension monitoring training begins with direct instruction and adult modeling followed by prompts which are eventually faded to

promote internalization (Miller, Giovenco, & Rentiers, 1987).

Haller, Child, and Walber (1988) conducted a meta-analysis of 115 comparisons drawn from 20 metacognitive studies. They found a median effect size of .57, rather large for an educational intervention. The largest effects were found with seventh and eighth grade students; the reading comprehension of fourth through sixth grade students was not affected as much. Among the metacognitive skills taught, training students to detect textual inconsistencies, and self-questioning strategies were the most effective.

Many studies have found that students who benefit the most from metacognitive training are those who are initially the most deficient in comprehension, such as learning disabled (LD) students. For example, Wong and Jones (1982), after training subjects to question themselves about the main idea, found that the comprehension of LD students improved significantly. However, they found no effect for the normally achieving students. A similar finding occurred in a study by Bos (1984). When cued to monitor their comprehension, LD readers improved significantly while the average group did not. Through metacognitive strategy training, some researchers (Miller, Giovenco, & Rentiers, 1987) have been able to raise the monitoring level of below average readers up to a level commensurate with that of their average and above average peers. On occasion, LD subjects have even outperformed regular students. Immediately after Chan, Cole, and Barfett's (1987) specific instruction intervention, LD students actually demonstrated higher levels of comprehension monitoring than average students.

When the nature of LD students' metacognitive deficiencies are examined it is no longer surprising that training in comprehension monitoring may lead to better performance. According to Hare and Smith (1982), readers with little metacognitive activity may even fail to perceive that their comprehension is lacking and are thus unlikely to employ any corrective reading strategies. However, it is more commonly believed that LD students and poor comprehenders may be aware that their understanding of text is insufficient but simply fail to take action that would rectify the situation (Chan & Cole, 1986). Cornoldi (1990) discovered that poor comprehenders do not even use the logical strategy of allocating more study time to the most difficult portions of the text. Lipson (1986) also found that poor comprehenders didn't alter their approach to the task as difficulty level increased.

Correlations between metacognitive awareness and performance (strategy use) were strongest for easier text (.45 to .60, $p<.05$) but weakened as text difficulty increased. Lipson concluded that a high degree of awareness and strategy use only benefitted poor readers when they process text which is relatively easy for them.

Informed training

Informed strategy training involves instruction in the significance of the trained activity (Brown, Armbruster, & Baker, 1986). Informed training provides trainees with a clear rationale for the strategy and informs them of the direct relationship between strategy use and beneficial effects on learning (Wong, 1985). If informed training is to result in conditional knowledge regarding when to use metacognitive strategies, then it needs to be designed so that the relevance and utility of the strategies become apparent to the readers (Paris & Oka, 1989). Paris and his associates (1984) have been leading proponents of informed training. Paris (Myers & Paris, 1978) developed a program known as "Informed Strategies for Learning" which promotes conditional knowledge through direct instruction and by providing readers with feedback on their performance when they use the newly acquired strategies. Paris (Myers & Paris, 1978) also contributed significantly to the research by developing and refining a structured interview which assesses a child's level of reading related metacognitive development.

The development of the informed training approach followed the failure of many earlier studies to demonstrate transfer and maintenance of comprehension monitoring skills. More recent investigations (Wong, Wong, Perry, & Sawatsky, 1986) have been able to demonstrate adequate transfer of new skills when there is an informed training component. Maintenance for up to six months (at a 60% level) was accomplished in an informed training program managed by Brown and Palinscar (1982). Another training approach that has achieved a durable and generalized effect is the reciprocal teaching method used by Palincsar and Brown (1984).

At times, informed strategy training will result in improved levels of reading awareness but does not lead to an improvement in standardized reading comprehension test scores (Paris, Saarnio, & Cross, 1986). Based on evidence of a consistent relationship between reading awareness and reading comprehension, it is usually assumed that an improved level of reading awareness should lead to more strategy use and ultimately a higher level of reading comprehension. Despite a

reading awareness score which was one standard deviation higher than that of the control group, third and fifth grade subjects failed to demonstrate increased reading comprehension in the study by Paris, Saarnio, and Cross. The authors and other investigators (McLain & Mayer, 1991) contend that standardized measures are insensitive to assessing improved strategic reading. It is argued that a cloze or error detection task might be a more appropriate assessment procedure.

Computer mediated text studies

Cognitive monitoring while reading computer text can be encouraged through the use of strategy prompts embedded in the text. Prompts can be statements like, "Look back," or "Ask yourself questions about what you are reading." Keene and Davey (1987) examined whether strategy cues in computer text would have a more advantageous impact than the same cues on the printed page. They did not find main effects for post-passage comprehension but did discover that computer use resulted in more frequent lookbacks.

Not only can computer programs be designed to mediate text but they can also provide instruction in comprehension strategies. Stevens (1986) wrote a program which taught subjects how to find the main idea and check main idea hypotheses. With a sample of students from remedial reading classes, Stevens found that computerized strategy training had a significant effect on the subjects' ability to identify the main idea. However, the effect did not transfer to new content.

Carrasquillo and Nunez (1988) have argued for the inclusion of comprehension monitoring prompts when reading comprehension software is designed. They compared the effectiveness of two different computer assisted metacognitive training programs on the comprehension of fourth grade ESL students in Puerto Rico. ESL students were considered to be comparable to poor readers with weak comprehension skills. While there were significant main effects for both treatments, the approach which followed up training with on-line modeling and strategy reminders was superior to the method which did not include modeling and reminders. Carrasquillo and Nunez concluded that computer mediated text can have a positive effect on cognitive and metacognitive processes during reading.

Salomon, Globerson, and Guterman (1989) tested the hypothesis that interaction with computer mediated text would lead to internalization of metacognitive strategies and improved reading comprehension. The subjects were a sample of seventh graders in Israel. Control groups read the same texts on

computer but did not receive metacognitive strategy training in advance or metacognitive prompts at the bottom of each screen as the experimental group did. The reading comprehension scores of the experimental group improved significantly; the comprehension scores of the controls did not. Also, the experimental subjects took significantly longer to read the text. Salomon et al. inferred that the longer reading time indicated that the subjects were dealing mindfully with the metacognitive guidance provided by the computer. In post treatment interviews, students reported that they had been expending mental effort, and they were able to reconstruct the prompted metacognitions. The subjects who had expended mental effort had better internalization of strategies. Salomon et al. concluded that computer mediated text can facilitate the development of comprehension skills.

Reinking and Schreiner (1985) developed a program which mediated text on an individual basis. Their program monitored each reader's progress and assisted those readers having comprehension difficulty. Those who were successfully comprehending could use options but were not required to do so. Options included key vocabulary definitions, a less technical version of the text, supplemental background information, and highlighting of the main ideas. Additional background information was chosen most often.

Reinking and Schreiner (1985) hypothesized that younger and poorer readers required minimal prompts to stimulate appropriate metacognitive activity, and if the readers could be encouraged to engage in metacognitive activity, their on-line comprehension would improve. Main effects for treatments were found. Groups reading computer mediated text performed better than groups which read computer text without assistance options. There was also a significant treatment by passage difficulty interaction. The on-line treatment groups scored higher on the more difficult passages than the off-line control group. Reinking and Schreiner (1985) also discovered that computer control of options had a more positive effect on computer passage comprehension than simply making options available for reader selection.

In a follow-up study, Reinking (1988) decided to investigate if comprehension is affected by whether the reader or the computer is more in control of the textual manipulations designed to aid comprehension. As in the earlier study, results indicated that the group in control of the textual manipulations did not do as well as

the group where manipulations were controlled by the computer. Reinking attributed the better performance of the latter group to deeper or more efficient cognitive processing.

In Reinking's most recent study (Reinking & Rickman, 1990), he found additional support for the claim that mandatory computer assistance leads to better comprehension of computer passages. Subjects were provided optional or mandatory assistance with the meanings of difficult words. It was assumed that readers have a tendency to focus on familiar aspects of the text rather than expend considerable effort to understand difficult words. The results indicated that computer mediated text can have a positive impact on comprehension and vocabulary learning. However, only subjects who were required by the computer to view the definitions of every target word actually scored higher on a comprehension test. The subjects who were allowed to choose which, if any, definitions to view, did no better than subjects reading conventionally printed pages.

The results of studies examining whether computer mediated text increases comprehension are equivocal (Reinking, 1988). In fact, Balajthy (1990) indicates that research has yet to yield any evidence that the computer's capabilities can be used to improve metacognitive functioning. In studies where increases in comprehension have been found, the computer was used to expand the reader's options for acquiring information from text and/or to control their processing of text (Reinking, 1988). In some studies, comprehension improved only when the computer controlled textual manipulations, and in other studies, comprehension increased only when readers were allowed to freely select computer assistance options (Reinking & Rickman, 1990). In conclusion, it appears possible that computers may enhance comprehension when they are purposefully used to effect more active processing of text (Reinking).

One of the reasons why computer mediated text may produce more efficient comprehension monitoring and more utilization of fix-up strategies is that computer mediated text reduces the cognitive processing load (Reinking & Schreiner, 1985; Salomon, 1990). For example, if the computer reduces memory load, readers do not have to rely heavily on their memories while carrying out a task, allowing them to engage in higher order thinking (Salomon, 1990).

The case for computer mediated text as a efficacious intervention with poor comprehenders is argued eloquently by Reinking (1988; 1989) and Salomon (1990). A computer mediated text program can be designed to serve as an active partner, affording opportunities that human interaction could also provide, but often does not (Salomon, 1990). Such programs can cultivate skills and strategies by activating them repeatedly. Salomon believes that children can internalize from a computer model, just as they do from an adult model.

Methodology

The sample was drawn from a parochial elementary school in an upper midwestern community of approximately 50,000 people. The subjects consisted of 38 fifth graders, 27 sixth graders, and 25 seventh graders for a total of 90. Within each grade subjects were randomly assigned to one of four experimental conditions.

The methodology was based on a 2 x 2 (text by training) factorial design. The computer text factor was whether the subject received computer text with or without computer assistance options. The strategy training factor was whether or not reading comprehension strategy instruction included an informed component. The treatment varied as follows:

Cell 1: Subjects (n = 23) received informed strategy training via computer assisted instruction and then read computer mediated text with options.

Cell 2: Subjects (n = 23) received informed strategy training via computer assisted instruction and then read computer mediated text without options.

Cell 3: Subjects (n = 22) practiced comprehension strategies on computer text without receiving any informed strategy training and then read computer mediated text with options.

Cell 4: Subjects (n = 22) practiced comprehension strategies on computer text without receiving any informed strategy training and then read computer mediated text without options.

Materials

Informed strategy training. An instructional software program was designed specifically for this study. The computer assisted instruction was adapted (with permission) from *Reading and Thinking Strategies* (Paris, 1989), a printed

curriculum designed for direct classroom instruction. The *Reading and Thinking Strategies* curriculum resulted from Paris' applied research on metacognition. It contains explicit instruction in reading strategies and emphasizes the utility and benefits of strategy use. Consequently, *Reading and Thinking Strategies* met this study's criteria for "informed" strategy instruction. The adapted software version used in the current study was comprised of eight 25 minute lessons in which students read the information, answered questions, and practiced strategies on the computer. Following each computer lesson, subjects completed a short pencil and paper exercise from the *Reading and Thinking Strategies* workbook. The original printed materials were designed for fifth and sixth grade instruction but in the current study the same program and materials were also used with seventh grade subjects. The program was written for Apple IIe microcomputers.

The computer lessons focused on the following strategies: planning for reading, making predictions, self-questioning, using context, using imagery, paraphrasing, summarizing, self-monitoring, and error detection. These nine strategies were selected from strategies taught in previous studies. In each computer lesson an attempt was made to enhance the students' conditional knowledge by explaining when and how strategies should be used and stressing the benefits of strategy use.

Non-informed strategy training. While the experimental group worked on informed strategy training lessons, the control group spent an equivalent amount of time working with a computer software program designed to encourage students to experiment with and develop their own comprehension strategies. They interacted with a commercial software product known as *Those Amazing Reading Machines* (MECC, 1986). The program did not contain any direct instruction in reading awareness or reading strategies. The authors of the program believe that students will develop and modify their strategies as they practice reading on the program. Most of the practice consists of detecting and correcting textual errors. Since this instructional approach is neither explicit nor "informed," it met this study's criteria for "non-informed" strategy instruction.

Computer mediated text. The second independent variable which subjects were exposed to was computer mediated text. All subjects interacted with a commercial software product known as *The Comprehension Connection* (Reinking, 1987b). It was developed by David Reinking and is very similar to the

experimental program used in his research (Reinking, 1988; Reinking & Schreiner, 1985). The program has five options for assistance---dictionary, easier passage, vocabulary, main ideas, and pictures. In addition, readers may also choose to reread all or part of the text. The experimental subjects had access to all of the computer assistance options. The control group did not have access to any of the assistance options but were permitted to reread text. The computer program for each grade level consisted of 20 passages arranged according to difficulty level. At the end of each passage there were five multiple-choice comprehension questions.

Procedures

The reading comprehension score from a pre-treatment administration of the *California Achievement Test* (CAT) (CTB/McGraw Hill, 1986) was recorded for each of the subjects who volunteered to participate. The normal curve equivalent (NCE) scores were used because they are standardized scores which have equal intervals. Pre-intervention student performance on the CAT comprehension subtest would later be used as a covariate in data analysis.

All treatments took place during the subjects' regularly scheduled computer classes. Subjects, in groups of seven, worked on the experimental and commercial computer programs for 25 minutes, two times per week for eight weeks. During all sessions, the experimenter or a trained assistant monitored and assisted the subjects while they proceeded with the computerized interventions.

During the first four weeks of the study experimental subjects completed eight informed strategy training lessons on computer while control subjects received non-informed strategy training on the computer. Upon completion of strategy training, all subjects took a computer administered reading awareness test. The 20 item multiple-choice test measured each subject's level of metacognitive awareness of reading and their knowledge of reading strategies. The awareness test items were very similar to the interview questions Paris and Jacobs (1984) used to assess metacognitive awareness level.

During the second four weeks of the study all subjects read expository text passages of approximatedly 300 words each and answered post-passage comprehension questions on *The Comprehension Connection* (Reinking, 1987b). Half of the subjects had options for assistance while the other half did not have options for assistance. Half of the subjects in each of the groups had received informed strategy training. The mastery level for all subjects was set at 80%, or

four out of five multiple choice questions answered correctly. Each set of five questions contained the following: one vocabulary question, one main idea item, one literal question, and two inferential items. Passages and questions could not be viewed simultaneously, nor would the computer provide assistance while questions were being presented. Students who did not obtain an 80% correct response level on the first attempt were required to study the passage further and then attempt the incorrect items again before being allowed to progress on to the next passage. During the first week of reading computer mediated text, students in the computer options group were required to try one of the assistance options if they did not achieve an 80% mastery on the first attempt. After the first week, students were free to choose whether or not to use computer assistance.

The 20 passages for each grade level were arranged according to difficulty level. All subjects worked on a program that was rated as one grade level higher than their actual grade placement. Each student was allowed to work at his/her own pace. All of the subjects were able to complete the sequence for a grade level (20 passages) and respond to a total of 100 multiple-choice questions in eight (or less) 25 minute sessions over a period of four weeks. While the students were reading computer mediated text, the computer management system tabulated the number and type of assistance options students selected while reading each passage. The computer also recorded each student's number of correct responses to post-passage comprehension questions.

Within a week after the last treatment session, the reading comprehension level of each subject was assessed with the standardized reading comprehension subtest from the *Kaufman Test of Educational Achievement* (K-TEA) (Kaufman & Kaufman, 1985). One week following the K-TEA administration, all subjects participated in their school's annual CAT testing. From this battery, subjects' reading comprehension answers were hand-scored and and the raw score transformed into (NCE) scores.

Finally, six subjects who had made frequent use of computer assistance options were selected for interviews. Of those interviewed, five of six had scored below the mean on the on-line comprehension questions. These interviews focused on the subjects' reactions to the treatments, their attitude towards reading computer text, their beliefs regarding the efficacy of computer mediated text, and their level of conditional knowledge.

Results

Hypothesis 1: Informed strategy training results in higher reading awareness/strategy knowledge

It was hypothesized that the subjects who had received informed strategy training (Cells 1 and 2) would have a higher post-intervention level of reading awareness and strategy knowledge than the controls (Cells 3 and 4). A right-tailed *t*-test resulted in a *t* value of 2.81, allowing the null hypothesis to be rejected ($p<.01$) and the experimental hypothesis to be supported. Subjects who received informed strategy training obtained significantly higher scores on the reading awareness test. The effect size was determined to be .65, a value which would appear to have practical significance. Table 1 contains group descriptive statistics.

Table 1 - *Descriptive Statistics for Reading Awareness Test*

	Experimental	Control
n	46	44
Mean	16.3	14.8
Median	17	15
Standard Deviation	2.8	2.4

Hypothesis 2: Informed strategy training leads to greater use of computer assistance options

It was hypothesized that the subjects who had received informed strategy training (Cell 1) would select assistance options more frequently than those who had not received informed training (Cell 3). The underlying assumption was that those with informed training would be monitoring their comprehension better and thus would select computer assistance options more frequently. In effect, taking advantage of available computer assistance was considered to be a reading comprehension "fix-up" or repair strategy. It was also thought that trained subjects would believe in the efficacy of employing strategies while reading.

The use of computer options by the group which had received informed strategy training was approximately double that of the control group. Almost all

subjects utilized more than one type of computer assistance. The on-line dictionary was used most often while the easier passage version of the text was chosen least often. The statistics in Table 2 are for the total number of options chosen while reading the 20 passages. The descriptive statistics reveal that the distribution was positively skewed for both groups. A few of the subjects selected options at a very high rate. A right-tailed *t*-test using a pooled variance estimate found support for the experimental hypothesis ($t(1) = 2.06$, $p<.05$). The effect size was 1.03, a relatively large effect size.

Table 2 - *Descriptive Statistics: Computer Option Selections by Type of Strategy Training*

	Informed	Non-informed	Total
n	23	22	45
Mean	26.9	14	20.6
Median	22	10.5	13
Standard Deviation	26.8	12.5	21.8

Table 3 - *Intercorrelation Matrix: Comprehension Measures, Reading Awareness, and Computer Option Use*

	Pre-CAT	Post-CAT	K-TEA	On-line	Awareness	Options
Pre-CAT	1.000					
Post-CAT	.800**	1.000				
K-TEA	.738**	.748**	1.000			
On-line	.778**	.803**	.759**	1.000		
Awareness	.252*	.366**	.262*	.381**	1.000	
Options	-.086	-.210	-.102	-.252	-.015	1.000

* p.<.05; ** p.<.001

Choosing computer assistance options was taken as an observable sign that the subjects were actively involved in monitoring their on-going comprehension.

Previous research (Chan, Cole, & Barfett, 1987) indicated a strong relationship between comprehension monitoring and comprehension. Consequently, it was thought that subjects who were more frequently taking advantage of computer assistance options would demonstrate higher levels of on-line comprehension. However, a review of the correlational data pointed to an opposite relationship (see Table 3). The use of computer options, which were designed to enhance comprehension, was negatively correlated with the on-line comprehension measure. In fact, selection of computer options had a slight negative correlation with the other measures of comprehension and the reading awareness level as well.

Hypotheses 3, 4, and 5: Computer mediated text with options and informed strategy training effects on comprehension: Main effects and interaction

Since the three measures of reading comprehension (on-line, K-TEA, and CAT) were highly correlated, a multiple analysis of covariance (MANCOVA) was conducted. The pre-intervention CAT scores were entered as a covariate, and adjusted means and standard deviations were obtained. Even after adjustment, there was no significant difference between the reading comprehension levels of the experimental and control groups.

A 2 x 2 (Training by Text) factorial analysis was also conducted with type of training (informed or non-informed) as one independent variable and type of computer text read (options or no options) as the other independent variable. Neither main effects nor interaction were found to be significant for any of the dependent measures (see Table 4). *F* ratios were too low to reject null hypotheses and therefore no support was found for the last three hypotheses.

No support was found for the hypothesis that computer mediated text with options for assistance leads to higher levels of reading comprehension. The group with access to computer assistance failed to demonstrate higher levels of on-line reading comprehension. The fourth hypothesis, informed strategy training leads to higher levels of reading comprehension, was also unsupported. The group that received informed strategy training actually had slightly lower means on all three measures of reading comprehension. The results also failed to support the fifth, or interaction hypothesis. Providing informed strategy training prior to reading computer mediated text with options, did not lead to improved on-line or post-intervention comprehension.

Table 4 -*Summary of Univariate F Tests: Cell Effect on Comprehension Tests*

Source	Variable	MS hypoth	MS error	*F*	*p*
Training	On-line	.51	23.89	.021	.884
	K-TEA	33.42	67.20	.497	.483
	CAT	53.07	107.00	.496	.483
Text	On-line	1.77	23.89	.074	.786
	K-TEA	79.97	67.20	1.200	.278
	CAT	1.68	107.00	.016	.900
Training X Text	On-line	2.49	23.89	.103	.750
	K-TEA	23.63	67.19	.351	.555
	CAT	22.15	107.00	.207	.650

(*df* =1,84)

Interviews

Interviews were conducted with five subjects who had selected computer assistance options at a very high rate (48 to 90 times) and with one subject who selected options only six times. Five of the six respondents indicated that they preferred reading on a computer instead of reading printed text. All but one of those interviewed had scored below the mean on the on-line comprehension questions. However, the four who had received informed training believed that computer assistance had improved their ability to respond correctly to the questions. Of the two who had not received informed strategy training, both were unsure about whether the use of the options had improved their performance. The two who had worked on the non-informed training program stated that it was fun and that the program had improved their reading, but they could not state specifically what it was they had learned.

Discussion

Informed strategy training delivered through computer assisted instruction appeared to significantly increase metacognitive awareness of reading and

knowledge of reading strategies and to significantly increase the use of computer assistance options. Thus, the computer training program seemed to accomplish its short-term instructional objectives. However, that advantage may have been of little practical value since the informed group showed no gains in reading comprehension. Computer mediated text also had no effect on reading comprehension. However, it did seem to encourage the use of computer assistance options (repair strategies), especially among those readers who had comprehension difficulties.

When the subjects who had received informed training interacted with computer mediated text, they clearly made more use of the computer assistance options. Choosing computer assistance options was taken as an observable sign that the subjects were actively monitoring their on-going comprehension. Thus, the results indicate that the informed strategy training may have led to increased levels of comprehension monitoring.

Previous research (Chan, Cole, & Barfett, 1987) indicated a strong relationship between comprehension monitoring and comprehension. Consequently, it was thought that subjects who were more frequently taking advantage of computer assistance options would demonstrate higher levels of on-line comprehension. However, the use of computer assistance options did not lead to improved on-line or post-treatment comprehension. It may be the case that more active comprehension monitoring and attempts to resolve comprehension failures do not necessarily lead to an immediate increase in reading comprehension. The fact that one recognizes a comprehension failure and tries to solve it does not ensure that the comprehension problem is resolved. Perhaps, more practice and implementation of the strategies is required before readers discover how to use the strategies effectively enough to impact comprehension. Also, some subjects may have selected assistance options at a high rate simply because informed strategy training convinced them that using strategies was very efficacious. For example, interviewed subjects from the informed training group firmly believed that use of computer assistance options would improve their on-line comprehension.

Interestingly, it appears that computer assistance options were chosen most often by the students the options were intended to help. An examination of the raw data and the intercorrelation matrix indicates that the students with low reading awareness/strategy knowledge and low comprehension scores were the most

frequent users of the assistance options. It appears that weaker comprehenders sought assistance from the computer more often than better comprehenders. Although there was no evidence that their use of the computer assistance options increased their on-line comprehension, their comprehension levels may have improved with a longer term intervention.

Using computer options may have failed to elevate comprehension because the strategy training did not specifically meet the needs of less capable comprehenders. With weaker comprehenders, mere possession of strategies doesn't guarantee effective use of strategies (Knight, 1989). Different strategies have different effects on comprehension (McLain & Mayer, 1991). There is evidence to indicate that poor readers do not pick an appropriate repair strategy when they encounter comprehension difficulties because they are unable to distinguish what is making the text difficult to understand (Goetz, Palmer, & Haensly, 1983). This could explain why the frequent use of computer options was negatively correlated with comprehension. Without a clear-cut understanding of the comprehension problem they were trying to solve, the weaker comprehenders were, as Balajthy says, "wandering about the courseware" (1990, p. 189).

There are a number of other reasons why informed training and increased awareness and strategy knowledge might not have had a measureable impact on comprehension. The first is that the controls may have gained more from their program than had been anticipated. Readers working on *Those Amazing Reading Machines* (the control group in the first half of the study) were actually forced to monitor their comprehension continuously as they confronted textual errors in all of their reading passages. It is assumed that they had to apply strategies in order to correct the text. Although the controls did not receive explicit training in strategies or learn relevant conditional knowledge, their practice may have been just as beneficial. Or, as Beal, Garrod, and Bonitatibus (1990) discovered, strategy training without emphasizing problem (error) detection may not be particularly helpful.

Also, the distinction between "informed" and "non-informed" strategy training that is often cited by Paris and his cohorts (Paris, Cross, & Lipson, 1984) may not be genuine. However, in fairness, Paris's (1989) training program was not fully tested because only part of the curriculum was delivered. Perhaps, more time to practice comprehension monitoring and strategies is required. It could also be that

computers are an inappropriate medium for the delivery of informed strategy instruction.

Finally, it is often argued that standardized reading comprehension tests are insensitive measures of what can be learned/gained from informed strategy training (McLain & Mayer, 1991). McLain and Mayer (1991) contend that standardized tests may measure background knowledge and overall reading ability rather than comprehension occurring during the reading process. Additional support for this contention has been provided by Paris, Cross, and Lipson (1984) who reported that trained subjects did better on cloze and error detection tasks but showed no improvement on standardized comprehension tests. However, in the current study the on-line reading comprehension questions would seem to be an appropriate and valid measure of immediate comprehension. Yet, no significant differences were seen with the on-line measure.

In the second half of the experiment, the difference between the experimental and control groups was the availability of computer assistance options. No main effect for mediated text with options was found; the subjects reading the same text without any computer assistance options did just as well on comprehension questions. The text should have been difficult enough to require metacognitive processing for most subjects; the reading level of the passages was approximately one year above the subjects' grade placement. It was also observed that the majority of the students had at least occasional difficulty reaching the criterion on the first attempt.

On the face of it, computer assistance would seem to encourage more active processing of the text and thus better comprehension. However, the reverse effect may occur. Additional information provided by the computer doesn't require additional cognitive processing. Reducing the cognitive load is seen as an advantage by some researchers (Salomon, 1990) because it is thought to allow more focusing on the extraction of meaning from text. But other researchers (Haynes, Kapinus, Malouf & MacArthur, 1985) have warned that programs like computer mediated text may encourage students to transfer responsibility for learning and active processing from themselves to the computer.

A critical goal of metacognitive training is that readers develop internal control over the knowledge and skills they acquire (Paris & Winograd, 1990). Perhaps computer mediated text with options counteracted the strategy training because it

failed to encourage internalization of strategies. Or, maybe the strategies taught during informed training were incongruent with the strategies supported by the computer mediated text program. For example, most of the computer options were designed to supplement prerequisite knowledge. To repair a prerequisite knowledge deficiency, a reader usually needs to consult a source outside the text. However, the informed training in the current study focused mainly on comprehension repair strategies that the reader can enact without consulting outside sources. The computer mediated text program used in this study may have done little to encourage use of the strategies which had been taught.

Conclusions

It appears doubtful that computer mediated text with options for assistance benefits immediate or long-term reading comprehension. Instead of encouraging more active comprehension monitoring and independent strategy use, mediated text may simply make an individual dependent on the computer for additional information and the processing of that information. While weaker comprehenders seem to seek more assistance from the computer, it is unclear whether such assistance improves their comprehension. It seems that computer assistance options are a poor substitute for independently generated strategies. It also seems unlikely that interaction with computer mediated text will lead to the internalization of better reading strategies.

Informed strategy training may be an effective classroom intervention when it is taught over an extended period of time. The current study may have been too brief; Paris, Saarnio, and Cross (1986) have pointed out that strategies take time to develop. Extensive practice is necessary if the new strategies and accompanying conditional knowledge are to be internalized and transferred. Adapting the complete curriculum to computer assisted instruction shows promise. How to assess the benefits of newly acquired metacognitive knowledge and strategies is difficult. Maybe measures of reading comprehension are the wrong avenue.

Many questions remain unanswered. It is evident that there is a need for more research on informed strategy training, comprehension monitoring, and computer mediated text, especially on how computer mediated text may affect comprehension monitoring.

Recommendations

Additional investigations might be able to answer some of the questions raised by this study by considering the following:

1. Similar investigations should draw samples from a population identified as having reading comprehension difficulties. The results of the current study may have been confounded by the fact that the sample contained too many high achievers.

2. Younger students (down to third grade level) should be selected for informed strategy training. Subjects in the current study possessed a significant amount of knowledge and skills prior to the training.

3. Better measures of comprehension monitoring and metacognitive processing need to be developed. Although the theory of metacognition as it relates to reading is well developed, the concepts are difficult to operationalize.

4. Computer mediated text needs to be more interactive. Perhaps the potential benefits of computer mediated text are unclear because the programs currently available do not allow enough genuine interaction between the reader and the computer.

5. Other factors which may intervene between metacognitive knowledge and reading comprehension need to be considered. For example, motivation may be one of the variables that accounts for why some readers fail to use strategies consistently.

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